SUBSTITUTE SPECIFICATION & ABSTRACT
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TITLE OF THE INVENTION

A METHOD OF MOUNTING A SEMICONDUCTOR LASER COMPONENT ON A SUBMOUNT

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method of mounting a semiconductor laser component on a submount.

2. Description of the Related Art

When a semiconductor laser component is used in systems such as an optical communication system, an optical disk, a laser, a laser-beam printer and the like, such element is packaged suitably for its use. In packaging the semiconductor laser component, a direct bonding method of directly bonding the semiconductor laser component to a component, which is disposed in the package, such as a metal block, a circular stem, and the like can be used. However, since a structure obtained through this method is simple while the heat releasing property of the semiconductor laser component is not good, temperature thereof increases and stress on the bonding phase is generated due to the difference in thermal expansion rates, and thus the lifetime of the semiconductor laser component is shortened. For this reason, it is difficult to use the direct bonding method in a high-power semiconductor laser component.

Therefore, in order to solve the above problem, there has been a method for mounting a semiconductor laser component on a submount made of SiC which is excellent in thermal conductivity and processability and has a thermal expansion rate close to that of the semiconductor laser component, and bonding the resultant semiconductor laser device to a package. Recently, a bonding method with a submount having an excellent heat releasing property is widely used.

Now, a conventional method of mounting a semiconductor laser component will be described. Figs. 6A-6C illustrate the processes of mounting a semiconductor laser component, wherein reference numeral 1 indicates a semiconductor laser component, 2 indicates a submount, 3 indicates a bonding member made of eutectic solder, 4 indicates a collet, and 5 indicates a heating table.

First, as shown in Fig. 6A, the submount 2 is set on the heating table 5 and then the submount is heated up to a temperature of 130°C or more at which the bonding member 3 on the submount 2 is melted. In the meantime, the semiconductor laser component 1 is held through vacuum absorption by the collet 4, and is positioned on the mount surface of the submount 2.

Next, as shown in Fig. 6B, after the bonding member 3 is melted, the collet 4 holding the semiconductor laser component 1 descends to mount the semiconductor laser component 1 on the bonding member 3 of the submount 2 and make it cooled. At that time, in order to secure sufficient bonding area between the semiconductor laser component 1 and the submount 2

sandwiching the bonding member 3 and to improve the heat conductivity by making the bonding member 3 thin, the semiconductor laser component is pressure bonded on the submount by the collet 4. Next, as shown in Fig. 6C, after the bonding member 3 is completely coagulated, the collet 4 releases the semiconductor laser component 1 and ascends.

The bonding method using the submount enables the semiconductor laser component to be high-powered. However, the higher-powered semiconductor laser component results in enlargement of the submount, and widening of the bonding area between the semiconductor laser component 1 and the submount 2 sandwiching the bonding member 3.

In this regard, the enlargement of the submount 2 and the widening of the bonding area accompanied with the higher-powered semiconductor laser component have caused the following problems. A volume of a substance is varied according to variation of temperature, and the rate of change (thermal expansion coefficient) of every substance is different. For this reason, when different substances are heated to bond to each other, a difference in temperature exists for a time period from the complete coagulation of the bonding member to the recovery to a normal temperature. Thus, a shearing force due to a difference in thermal expansion coefficient is generated in the bonded portion and this shearing force causes a residual stress in the substances. Further, the residual stresses are varied depending upon sizes and shapes of the substances and the residual stresses generated in the semiconductor laser component 1 increase with the

enlargement of the submount 2 because of the following reasons.

Figs. 7A to 7D are conceptual views illustrating variations in the residual stresses depending upon variation in size of the submount 2, in which of Figs. 7A and 7B are an overview and a conceptual view illustrating generation of stresses when the submount 2 is small. Figs. 7 C and D are an overview and a conceptual view illustrating generation of stresses when the submount 2 is large. When the thermal expansion coefficient of the semiconductor laser component 1 is large, a force acts on the semiconductor laser component 1 in a direction of decreasing the bonding area and a force acts on the submount 2 in a direction of maintaining the bonding area. When the submount 2 is small as in Fig. 7B, the force of maintaining the bonding area is a shearing force generated when the submount 2 below a bonding surface is compressed. When the submount 2 of Fig. 7D is larger than the submount 2 of Fig. 7B, the force of maintaining the bonding area is the shearing force generated when the submount 2 below the bonding surface is compressed and a shearing force generated when the remaining submount 2 at the periphery of the submount 2 in which the shearing force is generated is tensioned.

When the semiconductor laser components 1 have the same size as the submount 2 in the two cases, the shearing forces generated when the submount 2 is compressed are equal to each other. Therefore, the large submount 2 has the stronger force of maintaining the bonding area by the shearing force generated due to the tension, and this shearing force is

stronger with an increase in size of the submount 2. For this reason, the larger the submount 2 becomes, the stronger the shearing force acting on the semiconductor laser component 1 becomes. Therefore, the residual stress generated in the semiconductor laser component 1 increases with an increase in size of the submount 2. Furthermore, the same is true of the semiconductor laser component 1 having a smaller thermal expansion coefficient.

Furthermore, if the bonding area between the semiconductor laser component 1 and the submount 2 sandwiching the bonding member 3 is made large in order to enhance the heat conductivity, the residual stress of the semiconductor laser component 1 increases for the following reasons. When the semiconductor laser component bonded to another substance is cooled, compression occurs around a center of the bonding surface. For this reason, the farther a place is from the center, the greater the difference in the amount of compression between different substances becomes and thus the shearing force becomes lager. If the bonding area increases, places away from the center are bonded, and thus the shearing force becomes larger than the area ratio. For this reason, the residual stress due to this shearing force increases.

As described above, in order to secure a sufficient bonding area between the semiconductor laser component 1 and the submount 2 sandwiching the bonding member 3 and to improve the heat conductivity by making the bonding member 3 thin, the semiconductor laser component is

pressure bonded on the submount by the collet 4. However, since the semiconductor laser component 1 and the submount 2 are bonded with the stress generated due to the pressure bonding, the stress due to the pressure bonding remains in the semiconductor laser component 1 even after the release of the pressure bonding by the collet 4. At that time, if the bonding area enlarges, the fluid resistance of the bonding member 3 increases and thus the force required for the pressure bonding increases. For this reason, the residual stress remaining in the semiconductor laser component 1 due to the pressure bonding increases with the enlargement of the bonding area.

Moreover, since semiconductor laser devices are made up by means of a heating joint, the submount 2 and the joint plane of the semiconductor laser component 1 become high temperature, but since the collet 4 is not usually heated, the collet 4 and the contact surface of the semiconductor laser component 1 with the collet 4 are still low temperature. In the semiconductor laser component 1, a difference in temperature of more than 100 ℃ occurs at the time of mounting and the high temperature section expands by thermal expansion. Consequently, the semiconductor laser component 1, as shown in Fig. 8A, becomes curved. Then, if a semiconductor laser device is cooled in a cooling process, the semiconductor laser component 1 will finally be cooled to a uniform temperature and will be returned to the original flat form as shown in Fig. 8B. However, since the bonding member 3 is solidified in the curved form as shown in Fig. 8A, the semiconductor laser component 1 will be prevented from returning to the original form by cooling, and residual

stresses occur near the junction part.

In order to improve the heat releasing property, the submount 2 is bonded to the vicinity of a light emitting region of the semiconductor laser component 1. For this reason, the light emitting region is positioned at a zone having high residual stresses in the semiconductor laser component 1. Furthermore, for the semiconductor laser devices in recent years, not only a higher output of the semiconductor laser component 1 but also miniaturization and integration of a device are required. Therefore, in case of the conventional semiconductor laser device, the submount 2 is required to be used not only as the shock absorbing material and the heat dissipation member of the semiconductor laser component 1 but also as the other functional materials. Therefore, it becomes impossible to choose the quality of the material of submount 2 freely, and consequently impossible to fully achieve the original function of submount 2.

In general, when current flows in the semiconductor laser component 1 under a stress of 100MPa or more applied to the light emitting region, crystals are transposed, resulting in deterioration of the laser characteristic and destruction of the semiconductor laser component 1. This phenomenon occurs when the stress of 100MPa or more is applied to a part of the light emitting region. In addition, the higher-powered semiconductor laser component 1 makes the residual stress in the light emitting region larger, so that the deterioration of laser characteristic and the destruction of the semiconductor laser component 1 often occurs.

As described above, the residual stress of the semiconductor laser component 1 is generated locally due to various causes and the distribution of residual stress is variable due to sizes and shapes of the semiconductor laser component 1, the submount 2 and the collet 4, and the pressing force of the collet 4, etc.. Accordingly, there is no correlation between the macroscopic deformation (bending) and the residual stress of the semiconductor laser component 1, which makes it difficult to specify the cause.

SUMMARY OF THE INVENTION

In order to solve the above problems, it is an object of the present invention to provide a method of mounting a semiconductor laser component capable of preventing deterioration of laser characteristics and destruction of the semiconductor laser component due to residual stresses as well as preventing a decrease of a lifetime due to increase in temperature of the semiconductor laser component.

According to a first aspect of the present invention, there is proposed a method of mounting a semiconductor laser device which comprises a step of pressure bonding a semiconductor laser component on a submount by a collet while a bonding member is heated so as to be fused or melted on a submount by heating a table on which the submount is placed. For example, the table and the collet are heated to a temperature higher than a fusing point of the bonding member so as not to transfer the heat substantially to a collet, and then heating of the table and the collet are terminated while maintaining the

pressure bonding state, and the semiconductor laser component is released from the collet after all of the bonding members solidify.

Heating of the table and collet to a temperature higher than a fusing point of the bonding member is carried out so that the heat transfer does not substantially occur at the collet. Therefore, it is good to heat the collet to the same temperature as the heating table at the time of heating the table and the collet, and to give the same temperature profile as the heating table to the collet at the time of cooling of the semiconductor laser component, when controlling bending of a semiconductor laser component. The method of giving a temperature profile is not limited and can be carried out by controlling energization of an exothermic coil, for example.

Moreover, if a part near a contact surface of the semiconductor laser component is set to a lower temperature while a part near a contact surface of the collet is set to a higher temperature, a temperature difference there between causes the semiconductor laser component to be bent in a convex shape. On the other hand, a thermal expansion coefficient difference between the semiconductor laser component and the submount and a bonding pressure of the collet makes both the semiconductor laser components to be bent in a concave manner. Therefore, both bendings are negated mutually, so that the residual stress in the semiconductor laser component 1 will be preferably decreased.

Then, when the table and the collet are heated, it is desirable to heat the collet to a temperature that is higher than the heating table and to

maintain the collet at a higher temperature than the heating table at the time of cooling of the semiconductor laser component until the bonding member solidifies completely.

When the semiconductor laser component is held by the collet, it may be kept at room temperature. Heating of the semiconductor laser component can avoid a rapid temperature change of the semiconductor laser component, resulting in no degradation of laser characteristics or no breakage of a semiconductor laser component and shortening of the mounting time. Therefore, before holding the semiconductor laser component by the collet, it is preferable to heat the semiconductor laser component to the same temperature substantially as that of the collet. According to the method of mounting a semiconductor laser device of this invention, the semiconductor laser component can be released from the collet when a part of said bonding member solidifies.

In case of using the above method of partially solidification of the bonding member, it is preferable to use a bonding member comprising a plurality of materials having a different fusing point where a material having a higher fusing point will solidify first. At the time of partially solidifying, the semiconductor laser will be released from the collet.

Moreover, it is recommended to make a part of the bonding member solidify by forced air during pressure bonding of a semiconductor laser component by the collet.

According to the method of mounting a semiconductor laser device of

this invention, it is preferable that when holding the semiconductor laser component by the collet, the collet has a pair of sides, of which a contacting side has an area larger than that of a contacting portion contacted with the semiconductor laser component so as to cover the contacting portion of the semiconductor by the contacting portion of the collet.

In the present invention, it is preferable to use a collet having a contacting side face, a part of which contacts a semiconductor laser component and is made of a material with low heat conductivity. The remaining part of the contacting side face is not limited and preferably is made of a material having a lower heat conductivity

In the present invention, it is preferable that the semiconductor component is bonded near the macro-axis side thereof on said submount by said bonding members and the remaining parts contact the submount through a heat transmission member having low bonding power. The heat transmission member may be a material having a bonding power lower than that of the bonding member. The bonding member is preferably made of a material with a fusing point lower than an eutectic solder. As long as the material of bonding member has a fusing point that is lower than an eutectic solder, the specific type of material is not limited.

This invention has an effect which is indicated below.

According to the present invention, a semiconductor laser component is pressure bonded to the submount by a collet, while preventing the heat transfer to the collet. The semiconductor laser component is released from

the collet, after the heating of a heating table and the collet is terminated, and the pressure bond by the collet and the bonding member solidifys completely. Therefore, the residual stress caused by the difference of temperature in a semiconductor laser component can be decreased, so that degradation of laser characteristics or breakage of a semiconductor laser component can be controlled.

Moreover, according to the present invention, the residual stress caused by the difference of temperature in a semiconductor laser component can not generate because the collet is heated to the same temperature as that of the heating table, so that the heat transfer to the collet is prevented and then the same temperature profile as the heating table is given to the collet at the time of cooling of the semiconductor laser component, so that degradation of laser characteristics or breakage of a semiconductor laser component can be prevented.

Further, according to the present invention, since the residual stress due to the thermal expansion coefficient difference between the semiconductor laser component and the submount, and the residual stress due to the temperature difference in the semiconductor laser component negate each other by maintaining the collet at a temperature higher than the heating table until the bonding member solidifies completely at the time of cooling of a semiconductor laser component, degradation of laser characteristics or breakage of a semiconductor laser component can be prevented.

Moreover, according to the present invention, before vacuum adsorption of the semiconductor laser component, heating of the semiconductor laser component to the same temperature as the collet can prevent the heat transfer to the collet, thereby degradation of the laser characteristics due to rapid temperature change or breakage of a semiconductor laser component can be controlled, and the mounting time can be shortened.

Further, according to the present invention, the submount is installed on the heating table and the heating table is heated to a temperature higher than the fusing point of the bonding member, and the semiconductor laser component, which is vacuum absorbed by the collet, is moved to a loading position of the submount, and the semiconductor laser component is pressure bonded to the submount by the collet. And when heating of the heating table is terminated, with the pressure bonding by the collet, and the semiconductor laser device is cooled and a part of the bonding member solidifies, the semiconductor laser component is released from the collet. Thereby, the residual stress caused by the difference of temperature in the semiconductor laser component and the residual stress caused by pressure bonding by the collet can be decreased, and degradation of laser characteristics or breakage of a semiconductor laser component can be controlled.

Moreover, according to the present invention, the semiconductor laser component can be released from the collet after a part of the bonding member has solidified because the bonding member comprises two or more kinds of

the materials having a different fusing point. Thereby, the residual stress can be decreased and degradation of laser characteristics or breakage of a semiconductor laser component can be controlled.

Further, according to the present invention, since a semiconductor laser component can be made to be released from the collet after a part of the bonding member has solidified by forced air cooling at the time of the pressure bonding by the collet, the residual stress can be decreased and degradation of laser characteristics or breakage of a semiconductor laser component can be controlled.

Moreover, the residual stress caused by pressure (compression) bonding of the collet can be decreased by ensuring that the contact surface of a semiconductor laser component is smaller thatn the contacting surface of the collet which contacts the semiconductor laser component. Thus, when the collet is made larger than the field portion in which a semiconductor laser component is contacted and a semiconductor laser component is held by the collet, degradation of laser characteristics or breakage of a semiconductor laser component can be controlled.

According to the present invention, since the area of the collet that contacts with the semiconductor laser component is made larger than the contacting area of the laser component and the contacting area of the semiconductor laser component is enclosed by the contacting area of the collet when the semiconductor laser component is held by the collet, the residual stress due to the pressure bonding of the collet can be decreased and

degradation of laser characteristics or breakage of a semiconductor laser component can be controlled

Further, according to the present invention, since the collet has a contacting area made of the low heat conductivity quality of the material which prevents the heat transfer to the collet so as to decrease the residual stress due to a temperature difference in the semiconductor laser component, degradation of laser characteristics or breakage of a semiconductor laser component can be controlled

Moreover, since the residual stress of a luminescence range can be reduced without spoiling the heat dissipation capability of a semiconductor laser component by using the bonding member only near the macro-axis side of the planes of the semiconductor laser component, and positioning the heat transmission member between the submount and the semiconductor laser component, degradation of laser characteristics or breakage of a semiconductor laser component can be controlled.

Moreover, since the residual stress caused by the thermal expansion coefficient difference of the residual stress and the residual stress due to the difference of temperature in the semiconductor laser component and submount can be reduced by using a bonding member formed of a material having a fusing point lower than an eutectic solder, degradation of laser characteristics or breakage of a semiconductor laser component can be controlled.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objective and features of the present invention will become more apparent from the following description of the preferred embodiments thereof with reference to the accompanying drawings throughout which like parts are designated like reference numerals, and wherein:

Fig. 1 is a side view illustrating a process of mounting a semiconductor laser component according to a first embodiment of the present invention;

Figs. 2 A and 2B are side views illustrating processes of mounting a semiconductor laser component according to a second embodiment of the present invention;

Figs. 3A to 3B are side views illustrating processes of mounting a semiconductor laser component according to a third embodiment of of the present invention;

Fig. 4 is a side view illustrating a process of mounting a semiconductor laser component according to a forth embodiment of of the present invention;

Fig. 5 is a perspective view illustrating a process of mounting a semiconductor laser component according to a fifth embodiment of the present invention;

Figs. 6A to 6C are side views illustrating processes of mounting a semiconductor laser component according to the present invention;

Figs. 7A to 7D are conceptual views illustrating differences in residual stress depending upon different sizes in measurement of a submount; and

Figs. 8A and 8B are conceptual views illustrating generation of residual stresses by a collet.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Now, the following embodiments of the present invention will be described with reference to the above figures. In addition, the following particular form and particular structure of each part are examples of when the present invention will be applied to the embodiment. Therefore, the technical range of this invention is not limited by the examples and is not interpreted by these limitations.

Embodiment 1: Preventing the Heat Transfer to a Collet

Fig. 1 is a side view illustrating the process of mounting a semiconductor laser component. The semiconductor laser device comprises a based semiconductor laser component 1 having a light emitting portion, a submount 2 for mounting the semiconductor laser component 1, and a bonding member 3 for bonding the semiconductor laser component 1 on the mounting surface of the submount 2.

In the mounting method of the first embodiment of this invention, as shown in Fig. 1, the submount 2 is set on a heating table 5, and the submount 2 is overheated up to a temperature that is more than a melting

point of the bonding member 3 on the submount 2.

On the other hand, before holding the semiconductor laser component 1 by the collet 4, by using vacuum adsorption of the collet 4, the collet 4 is heated with the exothermic coil 6, and then the semiconductor laser component 1 is held and moved up to a loading position of the submount 2 (refer to Fig. 6A).

If the bonding member 3 fuses, the collet 4 holding the semiconductor laser component 1 will be dropped, the semiconductor laser component 1 will be carried on the bonding member 3 of the submount 2, and it will be cooled as it is.

At the time of heating and cooling the collet 4, the collet 4 should be heated to a temperature higher than a fusing point of the bonding member 3, and heating of the heating table 5 should be terminated at the same time as the heating of the collet 4 is ended, thereby the same temperature profile as the heating table will be given to the collet 4. The collet may be heated to a temperature higher than the heating table 5, and the collet 4 may be maintained at a temperature higher than the heating table 5 also at the time of cooling.

Moreover, in order to fully secure a bonding area between the semiconductor laser component 1 and the submount 2 through the bonding member 3, and to make the thickness of the bonding member 3 as thin as possible and to improve a heat-conducting characteristic, the semiconductor laser component is preferably pressure bonded by the collet 4 (see Fig. 6B).

When the bonding member 3 solidifies completely, the semiconductor laser component 1 will be released from vacuum adsorption of the collet 4, and will be raised by the collet, and a semiconductor laser device will be obtained (refer to Fig. 6C).

Next, referring to Figs. 1 and 8 an effect of this mounting method in the first embodiment will be explained.

In a conventional mounting method, a heating joint is carried out without the collet 4 being heated, and thereby the semiconductor laser component 1 will have a temperature difference of more than 100 ℃. Consequently, the semiconductor laser component 1 curves in a concave manner, as shown in Fig. 8A. Then, if a semiconductor laser device is cooled in a cooling process, the semiconductor laser component 1 tends to return to a flat form as shown in Fig. 8B. However, since the bonding member 3 is solidified in the concave state as shown in Fig. 8A, the semiconductor is prevented from returning to the original flat form when cooled, thereby residual stresses occur near junction parts.

Moreover, other residual stresses generate near the junction part, resulting from a difference of temperature and thermal expansion coefficient after the bonding member 3 solidifies completely until it returns to an ordinary temperature.

Generally, since the thermal expansion coefficient of the semiconductor laser component is larger than that of the submount 2, the semiconductor laser component 1 tends to return to its original form while

the semiconductor laser component is prevented from returning thereto, thereby creating residual stresses near the junction parts.

Furthermore, in order to improve a heat-conducting characteristic from the semiconductor laser component 1 to the submount 2, pressure bonding of the semiconductor laser component 1 by the collet 4, makes the bonding area of the bonding member 3 fully secured, and also makes the thickness of the bonding member as thin as possible.

Since the collet 4 pressure bonds the semiconductor laser component 1 at a center thereof, the semiconductor laser component 1 tends to curve in a concave manner.

Therefore, the semiconductor laser component 1 and the submount 2 are joined after a stress has occurred due to the by pressure bonding, and also after releasing the pressure bond of the collet 4, stresses created by pressure bonding remain in the semiconductor laser component 1.

Since all bendings that happen to the semiconductor laser component 1 by the three above-mentioned factors are in the same direction, if these factors overlap, the residual stresses will be doubled without negating each other.

These residual stresses will increase due to enlargement of the submount 2 and increase of the bonding area accompanied with the high-power semiconductor laser component. In order to improve the heat releasing property, the submount 2 is bonded in the vicinity of a light emitting region of the semiconductor laser component 1, and as a result, the

residual stress generated in the semiconductor laser component 1 is concentrated in the vicinity of the bonding surface with the submount 2. Therefore, the residual stress becomes higher in the light emitting region.

In general, when current flows in the semiconductor laser component 1 by applying a stress of 100MPa or more to the light emitting region, crystals are transposed, which deteriorate the laser characteristic or destroy the semiconductor laser component 1. Conventionally, since the residual stress was small in the semiconductor laser component 1, the destruction of the semiconductor laser component 1 due to the crystal transposition did not occur. However, with the increase of the residual stress accompanied by the recent high power, the semiconductor laser component 1 is destroyed due to the crystal dislocation.

In contrast, in this embodiment, in order to decrease the residual stress of the semiconductor laser component 1, as shown in Fig. 1, before holding the semiconductor laser component 1 by the collet 4, the collet 4 is heated by the exothermic coil 6 to a temperature that is more than a fusing point of the bonding member 3 and heating of the heating table 5 and the collet 4 is simultaneously terminated at the time of cooling.

The collet 4 is heated to the same temperature as the heating table 5, and if the collet 4 and the heating table 5 have the same temperature profile at the time of cooling and are cooled, a difference of temperature in the semiconductor laser component 1 at the time of mounting will be small, and a temperature distribution will become almost uniform, thereby bending due to

the difference of temperature will be prevented in the semiconductor laser component 1. Therefore, since it becomes impossible to generate the residual stress by the difference of temperature in the semiconductor laser component 1 which has been one of the primary causes of generation of residual stress, the residual stress in the semiconductor laser component 1 will be decreased and degradation of laser characteristics or breakage of a semiconductor laser component can be controlled.

Moreover, the collet 4 is heated to a temperature higher than the heating table 5, and if the collet 4 is maintained at a temperature higher than the heating table 5 also at the time of cooling, the temperature distribution in the semiconductor laser component 1 at the time of mounting will be a low temperature at an area near the contacting plane of the semiconductor laser component 1, contrary to a high temperature at an area near the contact surface with the collet 4 of the semiconductor laser component 1. Consequently, bending due to the difference of temperature in the semiconductor laser component 1 becomes convex-like, contrary to the former. Since the bending by difference of temperature in the semiconductor laser component 1 undoes the other bending caused by the other two factors mutually, the bending of the semiconductor laser component 1 can be decreased, and degradation of laser characteristics or breakage of a semiconductor laser component can be controlled.

In addition, the optimum value of the heating temperature for the collet 4 is determined by the quality of the material and the size of the

semiconductor laser component 1, the submount 2 and the bonding member 3.

Furthermore, before conducting vacuum adsorption with the collet 4, a rapid temperature change of the semiconductor laser component 1 at the time of vacuum adsorption and mounting is avoidable by heating the semiconductor laser component 1 to the same temperature as the collet 4. Degradation of laser characteristics, therefore rapid temperature change of the semiconductor laser component 1 or breakage of a semiconductor laser component can be controlled, and moreover, the mounting time can be shortened.

In addition, although the exothermic coil 6 is used for heating of the collet 4 in the above-mentioned embodiment, the collet may be heated by the other methods.

Embodiment 2: Elimination of Collet Pressure Bonding Solidification

Figures 2A and 2B are the side views showing the second embodiment of this invention. The same structure of the semiconductor laser device as in the first embodiment and the same method as a conventional mounting method are used. In this the second embodiment, the differences relative to the first embodiment are as follows.

In the first embodiment, before holding the semiconductor laser component 1 by the collet 4, the collet is heated to a temperature higher than a fusing point and heating of the table 5 and the collet are terminated

simultaneously at the time of cooling in order to decrease residual stress of the semiconductor laser component 1. In this embodiment, the semiconductor laser component 1 is released from the collet 4 after a part of bonding member 3 has solidified. Therefore, an effect of a mounting method in in accordance with the second embodiment can be explained according to Fig. 2.

Although the residual stress of the semiconductor laser component 1 is produced according to the following three factors such as a difference of temperature in the semiconductor laser component 1, a thermal expansion coefficient difference between the semiconductor laser component 1 and the submount 2, and pressure bonding by the collet 4, a part of the residual stress is generated by the difference of temperature in the semiconductor laser component 1 and pressure bonding of the collet 4 when the bonding member 3 solidifies in a state where the collet 4 touches the semiconductor laser component 1. That is, if the collet 4 is released from the semiconductor laser component 1 before the bonding member 3 solidifies, the generation of residual stress caused by the two above-mentioned factors can be prevented. However, when the collet 4 is released from the semiconductor laser component 1 before the bonding member 3 solidifies, it becomes impossible to manufacture a semiconductor laser device because the semiconductor laser component 1 moves from a predetermined position, and loses a desired function.

Therefore, if the collet 4 is released from the semiconductor laser component 1 after a part of bonding member 3 has solidified, since a part of

bonding member 3 has solidified, the semiconductor laser component 1 does not move from the predetermined position at the time of release of the collet 4.

Further, since most of the bonding member 3 has been fused, the collet 4 will be released from the semiconductor laser component 1 in the state where the semiconductor laser component 1 is curved due to pressure bonding of the collet 4, as shown in Fig. 2A. Then, as shown in Fig. 2B, the bent semiconductor laser component 1 will return to the original flat state, and the bonding member 3 solidifies completely in the state where there is no bending of the semiconductor laser component 1. According to this phenomena, the residual stress due to the two above-mentioned factors can be decreased, thereby degradation of laser characteristics or breakage of a semiconductor laser component can be prevented.

There is also a method using a bonding member 3, which comprises two kinds of the materials 31 and 32 having fusing points that are different from each other. By using the different kinds of materials 31 and 32 having fusing point that are different, the material portion 31 with a high fusing point solidifies first at the time of cooling of the semiconductor laser device, and if cooling progresses further, the material portion 32 with a low fusing point will solidify shortly. For this reason, since a time difference arises during solidification between the material portion 31 with a high fusing point and the material portion 32 with a low fusing point, after a part of the bonding member 3 has solidified, the collet 4 becomes releasable from the

semiconductor laser component 1.

As for the material portion 31 with a high fusing point of the bonding member 3, it is effective to use part of the periphery section of the bonding member 3, which is not in contact with the semiconductor laser component 1 and the submount 2. The reason is explained below. Since heat is generally emitted from the external surface of a solid, a central part is higher in temperature than the periphery section of the bonding member. That is, the periphery section of the bonding member 3 which is not in contact with the semiconductor laser component 1 and the submount 2 in the bonding member 3 serves as the lowest temperature part. Therefore, if a higher fusing point material 31 is positioned on the lower temperature part, the higher fusing point material solidifies first. After the higher fusing point material 3 solidifies, there is a long time until the material portion 32 with a low fusing point solidifies, so that it becomes easy to carry out the steps of the second embodiment. Moreover, there is a method of making a part of bonding member 3 solidify by forced air cooling at the time of pressure bonding by the collet 4 in accordance with a variation of the second embodiment. Forced air cooling makes the temperature near the external surface side of a semiconductor laser device descend remarkably as compared with the inside thereof, and a part of bonding member 3 can be solidified by means of forced air cooling with a cooling fan etc. at the time of cooling of a semiconductor laser device. Therefore, after a part of bonding member 3 has solidified, the collet 4 is releasable from the semiconductor laser component 1.

In addition, although the bonding member 3 is constituted from two kinds of materials having different fusing points in the above-mentioned second embodiment, the bonding member may be constituted from two or more kinds of materials in which the fusing points are different.

Embodiment 3: Exclusion of Uneven Pressure Bonding by a Collet

Fig. 3A and 3B are the side views showing the third embodiment of this invention. The same structure of the semiconductor laser device as in the first embodiment and the same method as a conventional mounting method are used. In the third embodiment, the differences from the first embodiment are as follows.

The third embodiment differs from the first and second embodiments in that the contacting side surface of the semiconductor laser component 1 in the collet is made to be larger than that of the contacting portion with the collet in the semiconductor, thereby the contacting area of the collet covers the contacting portion of the semiconductor laser component 1 when the collet holds the semiconductor laser component 1 by means of vacuum adsorption.

Next, the effect of a mounting method of the third embodiment as shown in Figs. 3A and 3B, is explained.

As one of the factors which cause the residual stress, the pressure bonding by the collet 4 the semiconductor laser component 1 is of important. Since the collet 4 is generally pressure bonding a center of the semiconductor

laser component 1, the semiconductor laser component 1 tends to curve in a concave manner. Therefore, the semiconductor laser component 1 and the submount 2 are joined after the residual stress has occurred due to pressure bonding by the collet 4, and also after releasing the pressure of the collet 4, the stress caused by the pressure bond remains in the semiconductor laser component 1.

When a field portion area of the collet which should contract the semiconductor laser component 1 is small, the pressure applied to the semiconductor laser component 1 at the time of forming the pressure bond becomes high as shown in Fig. 3A. Further, as the contacting portion of the collet is small, the pressure for pressing the semiconductor laser component will not be sufficient to prevent the semiconductor laser component 1 from bending. Therefore, bending of the semiconductor laser component 1 becomes large, and the residual stress increases.

On the other hand, when the area of a field portion of the collet 4 in contact with the semiconductor laser component 1 becomes large, the unit of load applied to the semiconductor laser component 1 becomes low if the same load is applied thereto. Further, since the collet has a large contacting area with the semiconductor laser component 1, the function of pressing the semiconductor laser component becomes strong, thereby bending of the semiconductor laser component becomes small and the residual stress is decreased. This tendency becomes strong when the field portion which the collet 4 contacts becomes large and becomes max when the contact surface of

the semiconductor laser component 1 becomes equal to the area of the field portion component 1 of the collet 4. For the above reason, since the residual stress of the semiconductor laser component 1 can be decreased, degradation of laser characteristics or breakage of a semiconductor laser component can be controlled.

Moreover, in the third embodiment, as shown in Fig. 3B, when vacuum adsorption of the semiconductor laser component 1 is carried out, the reason why the contacting portion of the collet always covers the contacting portion of the semiconductor laser component 1 is based on the following reason.

Although a contact position between the collet 4 and the semiconductor laser component 1, is based also on the accuracy of a mounting device, it is not always the same, and is changed with some gaps arising for every mounting, therefore even if such a gap arises, the larger contacting portion of the collet is enough to always covers the contacting portion of the semiconductor laser component 1.

Embodiment 4: Decrease of Residual Stress by Preventing Heat Transfer to a Collet

Figure 4 shows a temperature distribution in a side view showing the fourth embodiment of this invention in its height direction. The same structure of the semiconductor laser device as described in the first

embodiment and the same method as a conventional mounting method are used. In the fourth embodiment, the differences from the first embodiment is a point where the material with low heat conductivity is used near the contact portion with the semiconductor laser component 1.

Next, an effect of a mounting method in this embodiment is explained with reference to Fig. 4.

A difference of temperature in the semiconductor laser component 1 is one of the factors that generates residual stresses for the semiconductor laser component 1. Heat in the semiconductor laser component 1, which is heated to a higher temperature, transfers to a collet 4 having a lower temperature, thereby a difference of temperature arises in the semiconductor laser component 1 as shown in the characteristics (a) of Fig. 4A, and bending occurs.

That is, by preventing heat in the semiconductor laser component 1 from moving towards the collet 4, as shown in the characteristics (b) of Fig. 4B, temperature in the semiconductor laser component 1 can become almost uniform, and can decrease the residual stress of the semiconductor laser component 1.

Therefore, in the first embodiment, heating of the collet 4 prevents heat in the semiconductor laser component 1 from moving to the collet 4, and temperature in the semiconductor laser component 1 is kept uniform. On the other hand, in the fourth embodiment, since the collet 4 is made of the material of low heat conductivity near the contact portion with the

semiconductor laser component 1, it prevents heat in the semiconductor laser component 1 from moving to the collet 4, and temperature in the semiconductor laser component 1 is kept uniform.

For the above reason, since the residual stress of the semiconductor laser component 1 can be decreased, degradation of laser characteristics or breakage of a semiconductor laser component can be prevented or controlled.

Embodiment 5: Decrease of Residual Stress in the Luminescence Area

Figure 5 is the perspective diagram showing the fifth embodiment of this invention.

The same structure of the semiconductor laser device as in the first embodiment and the same method as a conventional mounting method are used. In the fifth embodiment, the differences from the first embodiment is a point where the semiconductor laser component 1 is bonded at near the macro-axis side by the bonding member 3 and intervened between either side of the bonding member by the low heat transmission materials.

Next, an effect of a mounting method in the fifth embodiment is explained with reference to Fig. 5.

Generally, in the semiconductor laser component 1 a luminescence range is arranged in the direction of a central macro axis near the contacting plane of the submount 2, in order to improve heat dissipation characteristics. Moreover, although the residual stress is produced according to the three factors such as a difference of temperature in the semiconductor laser

component 1, a thermal expansion coefficient difference of the semiconductor laser component 1 and the submount 2, and the pressure bonding by the collet 4. The residual stress is produced when the bonding member 3 solidifies, so that the residual stress is generated at junctions between the semiconductor laser component 1 and the submount 2. Therefore, a luminescence range of the semiconductor laser component 1 is positioned at a higher site of the residual stress in the semiconductor laser component 1.

Generally, in the semiconductor laser component 1 where a luminescence range is joined by a stress of 100 or more MPas, electric current pouring causes a possibility that crystal dislocation may happen and degradation of laser characteristics or breakage of the semiconductor laser component 1 may take place. Therefore, although a method of separating a part for a junction with the submount 2 from a luminescence range is effective in order to prevent breakage of the semiconductor laser component 1 due to the residual stress, if a luminescence range is separated from a junction, heat dissipation capability will decline, and in a short period it comes to cause breakage due to the heat.

Although it is necessary to arrange a contacting plane near the luminescence range, and to take the largest possible bonding area if the bonding member 3 is intervened between the semiconductor laser component 1 and the submount 2 from a viewpoint of heat dissipation capability. On the other hand, from a view point of bonding strength, since the bonding member may serves as a junction between the semiconductor laser

component 1 and the submount 2, it is not necessary to use the bonding member 3 for all the ranges where the semiconductor laser component 1 and the submount 2 contact each other.

Therefore, as a method of reducing residual stress of a luminescence range without spoiling heat dissipation capability, as shown in Fig. 5, the bonding member 3 is used only in a part of the contacting plane, i.e. near the macro-axis side which is most distant from the luminescence range and at the other junction portion without using the bonding member 3 the heat transmission member 7 of low junction nature is intervened. Therefore, the residual stress in a luminescence range can be reduced by of attaching the semiconductor laser component 1 to the submount 2, with the necessary minimum bonding member 3, thereby it is possible to arrange a junction used as a generating part of residual stress near the macro-axis side which is most distant from a luminescence range.

Moreover , since the heat dissipation capability is insufficient only by using the bonding member 3 near the macro-axis side of a plane of composition, the other parts other than bonding member 3 are required to provide the heat dissipation capability by intervening the heat transmission member 7.

Since the residual stress of a luminescence range can be reduced for the above-mentioned reason, without spoiling the heat dissipation capability of the semiconductor laser component 1, degradation of laser characteristics or breakage of a semiconductor laser component can be controlled.

In addition, although the bonding member 3 is arranged on the whole macro-axis side of a plane of composition in the above-mentioned embodiment, it may be arranged in a part of the macro-axis side.

Embodiment 6: Decrease of Residual Stress by Usage of Eutectic Solder

Next, the sixth embodiment of this invention is explained.

The same structure of the semiconductor laser device as in the first embodiment and the same method as a conventional mounting method are used. In the sixth embodiment, the difference from the above embodiments is a point where the bonding member comprises a material with a fusing point that is lower than an eutectic solder.

Next, an effect of a mounting method in the sixth embodiment is explained.

Although the residual stress is produced according to the three factors such as a difference of temperature in the semiconductor laser component 1, a thermal expansion coefficient difference of the semiconductor laser component 1 and the submount 2, and the pressure bonding by the collet 4. Among the three factors, the residual stress generated for the semiconductor laser component 1 produced according to a difference of temperature in the semiconductor laser component 1 and a difference of a thermal expansion coefficient between the semiconductor laser component 1 and the submount 2, a degree of the residual stress is influenced by the difference of temperature after the bonding member 3 solidifies until it

returns to an ordinary temperature.

Below, the reason is explained.

The residual stress due to difference of temperature in the semiconductor laser component 1 is produced by the following mechanisms. Although the submount 2 and the neighbor of the contacting plane of the semiconductor laser component 1 serve as a high temperature with heating at the time of mounting, since the collet 4 and the neighbor of the contact surface with the semiconductor laser component 1 serve as a low temperature because of no heating of the collet, a difference of temperature generates in the semiconductor laser component 1, at the time of mounting, and the semiconductor laser component 1 curves in a concave shape. If the bonding member 3 solidifies and is cooled to an ordinary temperature in this state, a force or tendency, which is acting to return the semiconductor laser component to an original flat form, functions, so that the force will turn into a residual stress which remains in the semiconductor laser component 1. Therefore, if a temperature, at which a junction solidifies, becomes low, bending of the semiconductor laser component 1 at the time of junction will become small, and the resulting residual stress will also become low.

Moreover, the residual stress caused by difference of a thermal expansion coefficient between the semiconductor laser component 1 and the submount 2 is produced by the following mechanisms.

The residual stress due to difference of temperature and also by difference of a thermal expansion coefficient after the bonding member 3

solidifies completely until it returns to an ordinary temperature, occurs near the junction part. Since the thermal expansion coefficient of the semiconductor laser component 1 is generally larger than that of the submount 2, the semiconductor laser component 1 is going to curve in a concave shape, but the movement of the semiconductor laser component 1 is prevented, so that a residual stress is generated near the joint part in the semiconductor laser component 1. Therefore, a temperature, at which the bonding member 3 solidifies, become low, so that bending of the semiconductor laser component 1 at the time of junction will become small, and the residual stress will also become low.

Generally, an eutectic solder is used for the bonding member 3 of the semiconductor laser device. Therefore, since the residual stress of the semiconductor laser component 1 can be decreased by using a material having a fusing point lower than an eutectic solder for the bonding member 3, degradation of laser characteristics or breakage of a semiconductor laser component can be controlled. This method may be used together with other mounting methods, and the residual stress can be further reduced.

Embodiment 7

In the above-mentioned embodiments 1-6, some residual stresses may still remain in the bonding section due to a difference of temperature after a bonding member 3 solidifies completely until the bonding member 3 returns to normal temperature, and also remain in the semiconductor laser

component 1 due to pressure bonding of a collet. In this case, the residual stresses are completely released by re-heating the submount 2 to a temperature that is higher than the melting point of the bonding member 3. Although the submount 2 can be heated in accordance with heating of the heating table 5, the submount may also be heated by means of a hot wind heating device, an electric heating device and a high frequency heating device.